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SITE Demonstration of the CHEMFIX Solidification/Stabilization Process at the Portable Equipment Salvage Company Site

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16. ABSTRACT

The CHEMFIX solidification/stabilization process was evaluated in the U.S. Environmental Protection Agency's SITE program. Waste from an uncontrolled hazardous waste site was treated by the CHEMFIX process and subjected to a variety of physical and chemical test methods.

The waste exhibited adequate physical properties. The treated waste generally met the regulatory leaching criteria established for the demonstration.

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The SITE Demonstration of the CHEMFIX Solidification/Stabilization Process at the Portable Equipment Salvage Company Site

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A demonstration of the CHEMFIX solidification/stabilization process was conducted under the United States Environmental Protection Agency's (EPA) Superfund Innovative Technology Evaluation (SITE) program. The demonstration was conducted in March 1989, at the Portable Equipment Salvage Company (PESC) uncontrolled hazardous waste site in Clackamas, Oregon. Waste containing lead, copper, and polychlorinated biphenyls (PCBs) from four different areas of the site were treated. Results showed substantial reduction of leachable lead and copper between the untreated waste and treated waste utilizing the EPA Toxicity Characteristics Leaching Procedure (TCLP) test. The effectiveness of this process for immobilizing PCBs could not be determined since the raw waste did not leach PCBs at high concentrations, utilizing the TCLP test. Data from other leaching tests for lead and copper would need to be utilized as input into a site specific groundwater model to determine whether solidification/stabilization would be an acceptable remedy for the site. Physical testing results indicated durability in exposed conditions.

The CHEMFIX process is a patented solidification/stabilization (immobilization) process utilized for the treatment of liquid, sludges, soils, and ashes containing heavy metals and organics. Soluble silicate reagents are normally added to the waste of concern. Three classes of reactions may occur:[1]

- Soluble silicates react with cations in the waste matrix to form immobile silicates;
- The silicious setting agents react with the remaining soluble silicates to produce a gel structure;
- Hydrolysis, hydration, and neutralization reactions also occur to further stabilize the waste.

The presence of certain organic constituents may necessitate the use of other additives to the process.

The equipment utilized for the treatment of the waste at the PESC site is schematically shown in Figure 1. Contaminated soils (screened to minus one inch) were excavated with a backhoe and delivered to an even feeder hopper. The soil was transported to an electrically monitored weight feeder via a conveyor. The waste was then introduced into a series of mixing equipment apparatus (homogenizer followed by a pug mill) where liquid reagent and dry liquid reagent were introduced. Reagent addition was controlled electronically. Additional make-up water was not always necessary, since the soils from the site were wet from the rainy conditions encountered. Treated wastes are normally transported to an on-site disposal area or transported off-site. CHEMFIX initially rated the capacity of the system utilized at this site for the demonstration at 100 tons per hour (tph).

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Demonstration Objectives

A Data Quality Objectives (DQO) program was utilized to define the objectives of the CHEMFIX process demonstration before site selection. Based upon performance claims and previous treatment data submitted by CHEMFIX, the following demonstration objectives were established:

- Evaluate the ability of the CHEMFIX process to meet or be below land disposal banning levels for heavy metals waste (specifically lead) established by the EPA;
- Determine the effectiveness of the CHEMFIX process (based upon percent reduction) to reduce the mobility of heavy metals (specifically lead and copper) and polychlorinated biphenyls (PCBs) after treatment utilizing the TCLP test;
- Determine physical properties of waste treated by the CHEMFIX process for reducing leaching potential and long-term durability indication.

Site Description

The PESC was selected as a demonstration site because the wastes present on the site were suitable for evaluating the demonstration objectives described above. The PESC site operated as a transformer and metals salvage facility from the early 1960s to 1985. Operations at the site involved scrapping

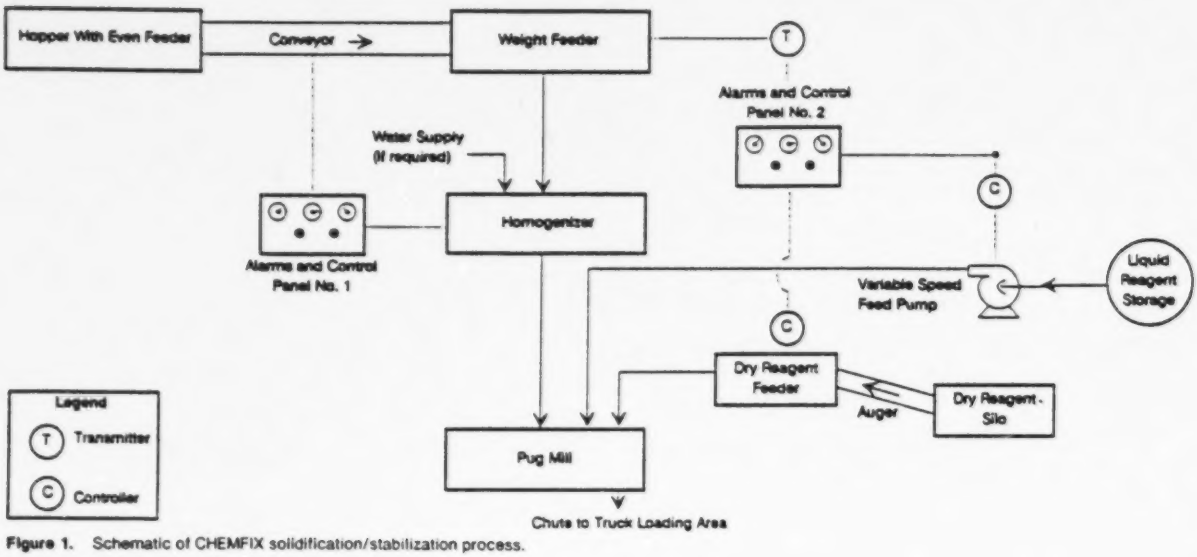

Figure 1. Schematic of CHEMFIX solidification/stabilization process.

and recycling power transformers containing PCBs in cooling oils. Salvageable metals from internal wiring and transformer carcasses were processed and recycled. Transformers and other recycled electrical equipment were burned in a furnace to eliminate insulation and other non-economic elements. Waste transformer oil was used to fire furnaces and metal smelters at the site.

Pre-demonstration sampling activities were geared at isolating waste areas that were sufficiently different in soil type or contaminant concentration to operate the process over a range of characteristics. This approach was aimed at defining the limits of the process for the site waste. Four selected areas were identified (see Figure 2) as having different characteristics and are described in Table I. The data showed ranges of contaminant concentrations and a large percentage of debris, which are common on uncontrolled hazardous waste sites. One of the areas contained an ash material as opposed to soil. It should be noted that some lead concentration values encountered were extremely high (up to 139,000 mg/kg).

Demonstration Program

Ten cubic yards of soil from each of areas A, C, and E and ten cubic yards of ash from area F were individually processed for this demonstration. The material was excavated, screened to minus one inch, and mixed on the ground by a backhoe to better homogenize the waste before treatment. Only a total of forty cubic yards of material were processed to minimize the amount of treated material that would be generated on-site. Process mixing performance was expected to be negatively impacted by processing such limited quantities of waste in a high capacity system, because calibration time would be limited. Area C soils were selected as the waste type where the majority of the physical and chemical testing methods would be performed.

The screened material was visually estimated to be about 30 percent of the total volume of material excavated. The quantities of all materials utilized were documented for mass balance purposes.

Sampling and Analysis Program

Raw soil samples were obtained the day of the demonstration and treated soil samples were taken immediately after processing. Leaching test samples were formed in plastic or cardboard molding tubes to eliminate destruction of samples or perceived interferences of leaching results from coring operations. Table II describes the leaching tests utilized in the demonstration.

Baseline physical and chemical tests were performed on the raw waste for comparison to treated waste samples. Table III lists the physical and chemical tests utilized in the demonstration. An air monitoring system with polyurethane foam (PUF) was employed to determine if PCBs were volatilized during the mixing or curing process.

Demonstration Results

Leaching Testing

Two values were established as the criterion for determining if the treated waste met the U.S. EPA land ban criteria for lead. The first value was 0.51 mg/L (TCLP leachate) based on the EPA standard for listed (F006 sludges) hazardous waste.[2] A second, higher level of 5.0 mg/L was arbitrarily chosen to recognize that soils may be more difficult to treat than sludges. Sixty-five percent of all samples tested from areas A, C, E, and F passed the 0.51 mg/L standard and 70 percent of these samples passed the higher standard of 5.0 mg/L.

Substantial reductions in the leachability of lead and copper in the raw waste, as determined by the TCLP,

Table I. Description of waste areas evaluated (pre-demonstration sampling) during the CHEMFIX site demonstration.

Area	Description
A	Soil—High lead and copper concentrations (10,000–139,000 mg/kg) Medium to high PCB concentrations (100–1,940 mg/kg)
C	Soil—High lead and copper concentrations (up to 117,000 mg/kg) High PCB concentrations (up to 1,350 mg/kg)
E	Soil—High lead and copper concentrations (up to 110,000 mg/kg) Low PCB concentrations (<100 mg/kg)
F	Ash—High lead and copper concentrations (40,000–136,000 mg/kg) Medium PCB concentrations (200–300 mg/kg)

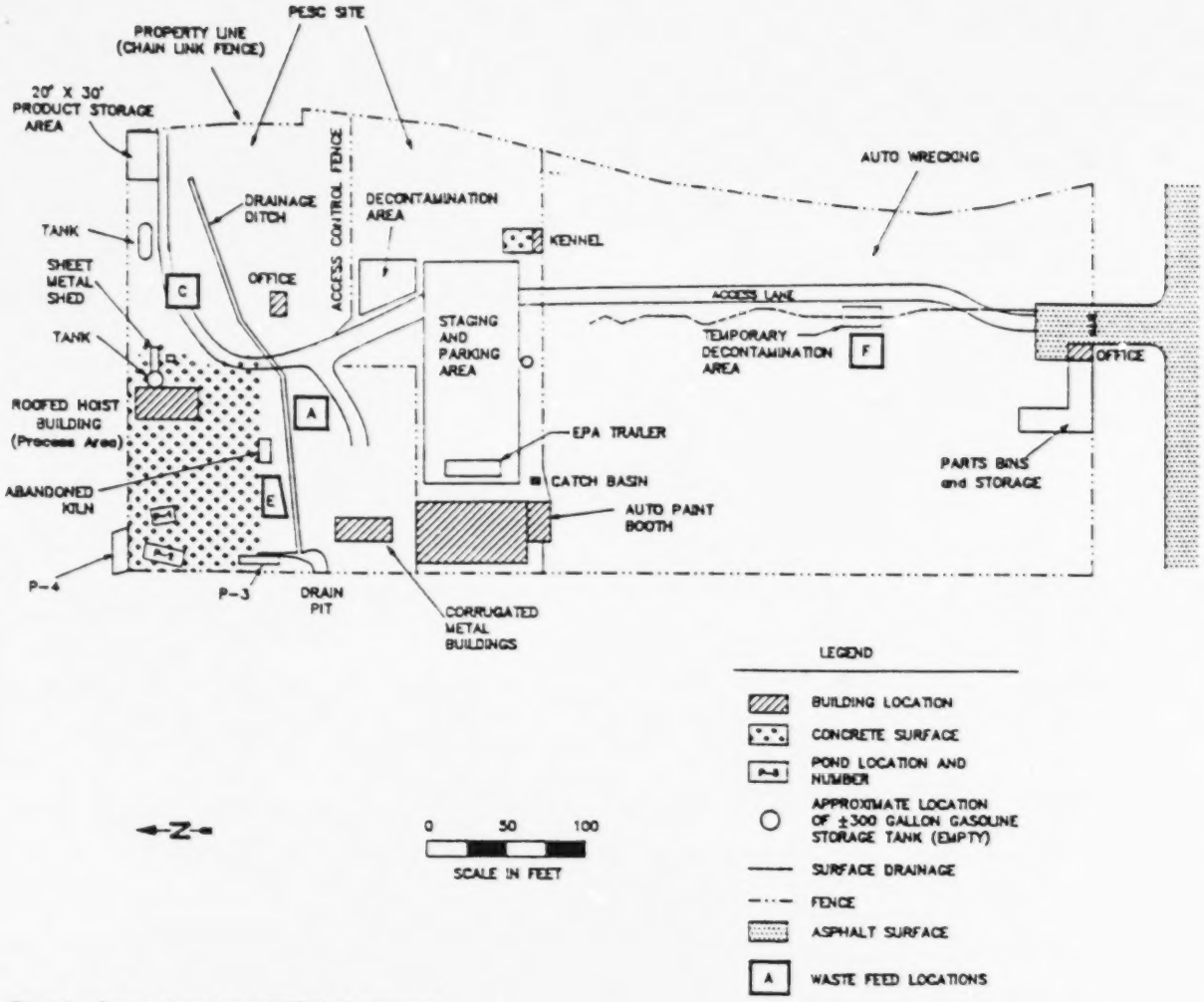

Figure 2. Four selected areas of PESC Site for treatment.

were observed. Table IV shows that lead reductions ranged from 94 percent in area E to 99 percent in areas A, C, and F. Copper reductions ranged from 95 percent in area C to 99 percent in areas A, E, and F. Data from these TCLP results need to be kept in the limited perspective that this test simulates a leaching environment involving co-disposal with municipal waste. This scenario may not have applications for the PESC site.

The reduction in mobility of PCBs, based on the TCLP, could not be determined since the PCBs essentially did not leach in the raw waste. More stringent leaching or extraction tests would be necessary to determine the effectiveness of this process for stabilizing PCBs.

Data from the MEP test were nonconclusive. In many instances, a criterion of 5.0 mg/L for lead was exceeded during the first extraction, but was not

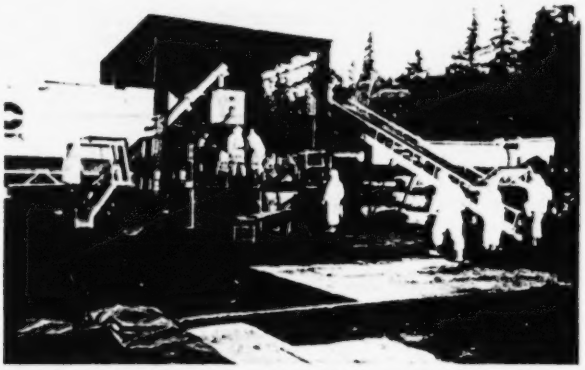

Figure 3. View of Chemfix solidification/stabilization processing unit during SITE demonstration.

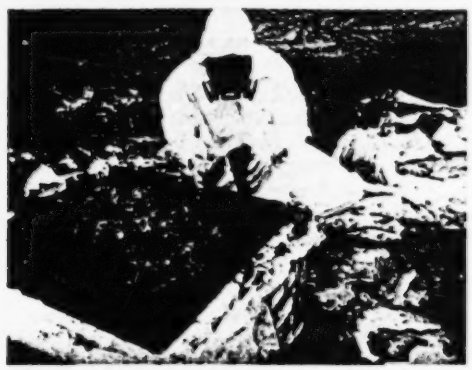

Figure 4. Technician obtains samples of treated waste material during SITE demonstration.

Table II. Leaching test utilized in the CHEMFIX SITE demonstration.

Name of Test	Reference	Description
TCLP	40 CFR Part 268	Ground material subject to 18-hour extraction process with acetic acid leachant to simulate co-disposal environment with municipal waste
MEP	EPA method 1320 (SW 846)	Ground material subject to 24-hour extraction with acetic acid leachant followed by nine sequential extractions with acidic rain simulated leachant
ANS 16.1	American Nuclear Society 16.1	Monolithic material placed in distilled water that is replaced over discrete time intervals (diffusion model)

exceeded during the nine subsequent leaching extractions.

Data from the ANS 16.1 test for lead and copper is presented in Table V. Leaching data is calculated into a leachability index (LI) which is the negative logarithm of the effective diffusivity coefficient. The treated material successfully exceeded the Nuclear Regulatory Commission (NRC) criterion for LI of six by several orders of magnitude.[3] However, the acceptability of these results, based on protection of the public health and environment, should be judged only after leaching values (fluxes) are incorporated into a site specific ground water model.

Chemical Testing

Data from chemical testing between the raw and treated material can be seen in Table VI. Oxidation/reduction potential of the treated waste was less than the raw waste. Conductivity of the treated waste was excessively higher than the raw waste, indicating that ions are leaching from the treated material. However, loss of ions into solution may not be of concern, depending upon the chemical nature of the ions. The pH of the raw waste, 6.6, increased to 11.5 after reagent addition. The pH of the treated material was not impacted to a large degree by the acetic acid leachant of the TCLP.

The air monitoring data suggested that there was no significant volatilization of PCBs during the treatment operations at the site. It should be noted that the wet, cooler temperature environment encountered during the demonstration would not promote volatilization.

Physical Testing

The results of the physical test performed on the treated wastes are shown in Table VI. Weight loss during wet/dry and freeze/thaw cycle testing was less than one percent. These data indicated durability in an exposed enviroment. Unconfined compressive strength (UCS) values ranged for 27 pounds per square inch (psi) to 307 psi. The EPA guidance value for solidified/stabilized waste for UCS is 50 psi.[4] Hydraulic conductivity of the treated material was in the range of 1×10^{-6} to 1×10^{-7} cm/sec. Acceptable hydraulic conductivity values should be compared to in-situ permeability measurements, which were not obtained at the site. The volume increase in the waste excavated material after treatment ranged from 20 to 50 percent.

Table V. ANS 16.1 leachability index (LI) data from the CHEMFIX SITE demonstration.

Contaminant	LI
Lead	13.2
Copper	15.2

Table IV. Mean concentrations of lead and copper from the CHEMFIX demonstration.

	Untreated waste (total)	TCLP from untreated waste	TCLP from treated waste	Percent reduction of TCLP extractable metal
Area A				
Lead	21,000 mg/kg	610 mg/L	<0.05 mg/L	99
Copper	18,000 mg/kg	45 mg/L	0.57 mg/L	99
Area C				
Lead	140,000 mg/kg	880 mg/L	2.5 mg/L	99
Copper	18,000 mg/kg	12 mg/L	0.54 mg/L	95
Area E				
Lead	92,000 mg/kg	740 mg/L	47 mg/L	94
Copper	74,000 mg/kg	120 mg/L	0.65 mg/L	99
Area F				
Lead	11,000 mg/kg	390 mg/L	0.10 mg/L	99
Copper	33,000 mg/kg	120 mg/L	0.60 mg/L	99

Table III. Physical and chemical test utilized in the CHEMFIX SITE demonstration.

Name of test	Reference	Description
Unconfined compressive strength (UCS)	ASTM D1633	Used to assess structural integrity of monolith
Hydraulic conductivity	EPA draft protocol	Used to assess resistance of material to water flow
Wet/dry resistance	ASTM D 4843	Indication of durability in wet/dry environment
Freeze/thaw resistance	ASTM D 4842	Indication of durability in freeze/thaw environment
Oxidation/reduction	EPA method 9045 (modified)	Determine oxidation/reduction state of waste matrix
Electrical conductivity	ASA 10.-3.3	Determine amount of ionic materials present in solution

Conclusions

The majority of the treated waste samples from the CHEMFIX solidification/stabilization process met land ban standards criteria established for the demonstration. Reductions of leachable lead, judged by the TCLP test ranged from 94 to 99 percent. Data from the ANS 16.1 test successfully exceeded the NRC criterion of six by sev-

Table VI. Physical and chemical properties of treated and untreated wastes from Area C of CHEMFIX demonstration.

	Area C	
	Untreated wastes	Treated wastes
Eh (millivolts)	290	24
Conductivity (umhos/cm)	130	3200
pH	6.6	11.3–11.5
28-day UCS (psi)	N/A	27–307
Wet/dry stress weight loss	N/A	<1%
Freeze/thaw stress weight loss	N/A	<1%
Hydraulic conductivity (cm/sec)	10^{-4} to 10^{-6}	10^{-6} to 10^{-7}

eral orders of magnitude, but this data needs to be incorporated into a site specific groundwater model before the performance of the process can be judged for this site.

The CHEMFIX process generally produced treated material with acceptable physical properties. The treated material had properties that indicated long-term durability in exposed environments. Volume increase in the excavated material after treatment ranged between 20 to 50 percent.

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